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A HAND BOOK TO THE  
WAXED PAPER PROCESS IN  
*Photography*

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LONDON  
CHAPMAN AND HALL PICCADILLY  
MDCCCLVII.





## PREFACE.

**T**HE general outline of the following Work is founded on the "Description of the Waxed Paper Process employed for the Photometeorographic Registrations at the Radcliffe Observatory," a paper which forms a supplement to their volume of observations for the year 1854.

Having been occupied for some time in superintending and arranging the meteorological department of the above observatory, I was, on leaving, requested by the talented observer, M. J. Johnson, Esq., to place on record for the benefit of their staff a description of the photographic process which I had so successfully introduced for recording the

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observations in their meteorological instruments: viz. the Barograph and Thermo-graph of Mr. Ronald's construction, and a Pluviograph designed and made by myself.

The experiments which I found it necessary to undertake, ere I arrived at the above results, occupied my unremitting attention for upwards of a twelvemonth, and were conducted on a scale commensurate with the great importance of the object which I had in view.

A vast number of the facts thus brought under my notice relate to points of chemical, optical, and photographic science which are alike common to every branch of the Art. Some few, necessarily, apply merely to the especial purpose which then engaged my attention; whilst others are only applicable to the Waxed Paper Process for the ordinary requirements of the photographer.

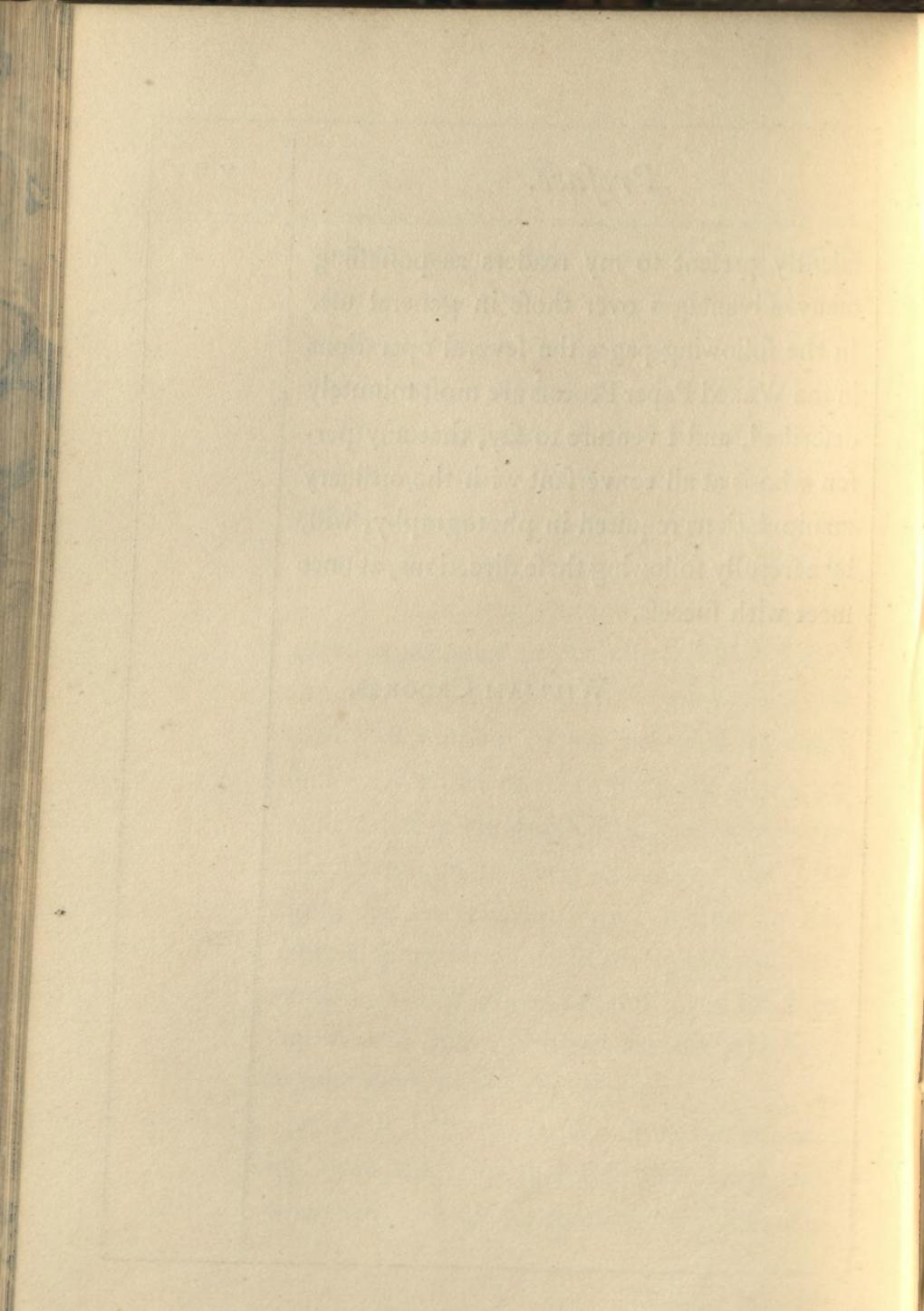
Latterly I have occupied myself in extracting from these innumerable data, materials wherewith to build a process which I can con-

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fidently present to my readers as possessing many advantages over those in general use. In the following pages the several operations in the Waxed Paper Process are most minutely described, and I venture to say, that any person who is at all conversant with the ordinary manipulations required in photography, will, by carefully following these directions, at once meet with success.

WILLIAM CROOKES.





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## THE WAXED PAPER PROCESS IN PHOTOGRAPHY.



THE Waxed Paper Process appears to me to be more particularly applicable to the ordinary requirements of the tourist or amateur in general than any other paper process whatever. The various operations, though numerous and at first sight rather complex, are of such a kind as to be easily reducible to practice, so that I believe average results can be obtained by this method with a smaller share of manipulatory skill than is required in most other paper processes.

In sharpness it may be made to rival Collodion, and though it cannot approach the latter in its exquisite sensitiveness, it will give place in this point to none of the ordinary modifications of the Calotype Process. Its

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chief superiority, however, consists in its capability of remaining sensitive for so long a time that it is of little consequence whether the sensitive sheets be a day or a week old. Then the comparative slowness of the development, which is generally looked upon as one of its weak points, may just as fairly be called a positive advantage, as it dispenses with that care and attention which must always be bestowed upon a quickly developing picture.

2. The Waxed Paper Process does not materially differ in principle from the original Calotype: iodide of silver is formed by double decomposition on, or rather in, the pores of a sheet of paper. This iodide is made sensitive to light by means of a slight excess of nitrate of silver; and, after exposure, the decomposition commenced by the light is continued by bringing the iodide of silver in contact with a mixture of nitrate of silver and a reducing agent, such as gallic acid; and, eventually, the unreduced iodide is dissolved away from the metallic silver by hyposulphite of soda or some other convenient solvent.

In the Calotype Process the principal difficulty is, the selection of a good, well sized,

and compact paper ; for unless this be exceedingly good in quality, the size is liable to be dissolved out during the numerous washings to which it is subjected. This renders it not only difficult to handle without tearing, but, by allowing the chemicals to sink into the paper whilst the cement which bound the fibres together has been removed, tends to produce a rough, indistinct appearance in the outlines of the picture.

3. To obviate this difficulty it was proposed by Legray to stop up the pores of the paper with wax, and by this means convert the soft spongy material into a hard impervious medium like parchment. Long soaking in a solution of iodide of potassium, or slightly washing in a weak solution of isinglass in water, will remove the greasiness from the surface, and then most beautiful pictures can be obtained on it either by Talbot's original formula, or, as is more generally employed, by that modification of it which has been found most suitable to paper of French manufacture.

4. The several operations in the Waxed Paper Process may be conveniently divided into six parts : viz. waxing, iodizing, exciting,

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exposing, developing, and fixing : but before entering into the practical details of these operations it may not be without service if I give a short description of some of the apparatus which is more particularly required in this process, together with a few remarks on the chemicals, &c. which are in most frequent use.

5. In this, and in fact in every other photographic process, the means adopted for illuminating the so-called dark room is of the first importance.

The results of some very numerous experiments, tried during the spring and summer of 1853,\* satisfied me that the rays which were active on iodide or bromide of silver have a fixed and definite boundary line in the solar spectrum ; consequently, in the selection of a transparent illuminating medium for the window of a photographic laboratory, it is a desideratum to find one which may admit abundance of light, and still filter off, as it were, these chemically acting spectral rays.

6. When iodide of silver is exposed to a pure spectrum for a space of time insufficient

\* Vide Photographic Journal, vol. i. p. 100.

to darken it visibly, and then the image brought out by a developing agent, it is only affected by the rays more refrangible than  $\frac{1}{6}GH^*$  forming the indigo, violet, and invisible part of the spectrum, the maximum effect being between  $\frac{1}{6}GH$  and  $H_{k1}$ , comprising the indigo and lower two-thirds of the violet. On

\* When referring to any point in the solar spectrum not corresponding with one of Fraunhofer's fixed lines, I adopt the nomenclature given by Professor Stokes in his paper (*Phil. Trans.* 1852, part II. article 24). I cannot describe it better than in his own words:—

"The position of a point in the spectrum which does not coincide with one of the principal fixed lines, will be denoted by referring it to two of those lines, in a manner which will be most easily explained by an example. Thus  $\frac{1}{2}GH$ ,  $G\frac{1}{2}H$ ,  $GH\frac{1}{2}$  will be used to denote respectively a point situated at a distance below  $G$  equal to half the interval from  $G$  to  $H$ , a point midway between  $G$  and  $H$ , and a point situated at the same distance above  $H$ . In using this notation, the letters denoting fixed lines will be written in the order of their refrangibility, and the fraction expressing the part of the interval between these lines, which must be measured off in order to reach the point whose position it is required to express, will be written before, between, or after the letters, according as the measurement is to be taken from the first line in the negative direction, from the first line in the positive direction, or from the second line in the positive direction, the positive direction being that of increasing refrangibility."

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replacing the iodide of silver by bromide of silver, the result shows equally conclusively the existence of a definite boundary line of action, the darkening being produced only by the rays above the band *b* (between E and F) forming three quarters of the green, together with the blue, indigo, violet, and invisible spaces, the maximum being between *b* and H k 1, comprising three quarters of the green, the blue, indigo, and two-thirds of the violet.

7. These results show how unsafe and imperfect an illuminating medium yellow calico is for such a purpose. One thickness, it is well known, allows white light to pass; consequently an increase in the number of folds merely diminishes the amount of transmitted white light, and in the same degree obstructs the illuminating yellow light.

8. On examining some pieces of glass of different colours with the spectrum, I found several which would answer the purpose. From these I picked out one of a deep orange colour, as being the more suitable. It was perfectly opaque to rays above Frauenhofer's line E (from the green upwards), but transmitted the lower luminous rays with facility. I had

a piece of the glass, nearly a foot square, fitted into the shutter of my room, and although during one part of the morning the sun used to shine directly through it on to the glass bath (uncovered) in which perhaps a collodion plate was being excited, I could not trace a single failure to this cause; and while, in point of security, it was at least equal to four or five thicknesses of yellow calico, it was incomparably more pleasant to work by, as when the sun was shining, the darkest corners of the room were illuminated as if by daylight.



## MATERIALS EMPLOYED IN THE PROCESS.



HE following is a list of the materials which will be found either necessary or useful in the process :—

- Several dishes.
- Brushes for cleaning ditto.
- Vessel for melting wax.
- Lamp furnace.
- Box iron.
- Still for water.
- Platinum spatula.
- Funnels and stand.
- Several measure glasses, from 1 drachm to 1 pint.
- Glass flasks.
- Scales and weights.

Sponge, glass rods, stoppered bottles, &c.

Photographic paper.

Blotting and filtering paper.

Wax.

Iodide of Potassium.

Milk Sugar.

Nitrate of Silver.

Acetic Acid.

Gallic Acid.

Alcohol.

Hyposulphite of Soda.

Cyanide of Potassium.

Nitric Acid.

Distilled Water.

10. The dishes may be made of glass, porcelain, or gutta percha. Glass and porcelain are certainly cleaner than gutta percha; but for general use the latter is far preferable, as with it there is no risk of breakage, and the bottom of the dish can be made perfectly flat, which is a great advantage. They should be of a sufficient size to allow of about half an inch margin round the sheet of paper. The gutta percha should be of a good thickness, otherwise it will bend and give way, if it be moved when full of liquid. The depth must

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depend upon the size of the dish, and the purpose for which it is intended; for ordinary work a very good rule is to make the depth a tenth part of their diagonal measure across, but for the iodizing or fixing baths they should be double the above depth, or one fifth. Each dish ought to be reserved for a particular solution, and should have for a cover a piece of mill board a little larger than itself.

11. The brushes for cleaning the dishes are of two sorts; a common scrubbing brush will be found the best for all parts but the corners, and for these another kind must be used, having a handle about a foot long, at the end of which are tufts of stiff bristles, projecting about three quarters of an inch, and radiating on all sides, forming a ball about two inches and a half in diameter. Hardly any dirt will be found capable of resisting this brush, if it be pressed into a corner, and twisted round several times. The dishes ought always to be put away clean, as the dirt is much more difficultly removed if allowed to dry on.

12. When a dish is to be cleaned, if it be of glass or porcelain, strong nitric acid must

be poured into it; if of gutta percha, it should be filled with a strong solution of cyanide of potassium. After soaking for half an hour or an hour, according to the state of the dish, the liquid is to be returned into the bottle, (both the nitric acid and the cyanide can be used several times,) the dish rinsed out with water, and then well scrubbed in every part with the brushes; afterwards it is to be washed several times in common water, once with distilled water, and then placed in a flanting position against a wall, face downwards, to drain on clean blotting paper.

13. The vessel in which the wax is melted, must be contrived so as never to allow of its reaching a higher temperature than  $212^{\circ}$  Fahr., or decomposition of the wax might ensue. I have found the most convenient apparatus to be a tin or copper vessel, of a sufficient size to allow a sheet of paper to lay loosely in it, and 4 inches deep, having a tray which holds the wax fitting into it about 1 inch deep. The under vessel is to be half filled with water, and by keeping this at the boiling temperature, the wax above will soon become liquid.

14. If gas is not conveniently attainable,

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the water may be heated either by an oil lamp furnace, or spirit lamp : but otherwife the best source of heat is that known as the gauze gas burner, it being free from smoke or dust, and not liable to blacken anything placed over it. It consists of a common argand burner fixed on a rather low and heavy iron stand, which is surmounted by a copper or brass cylinder 5 inches in height and 2 inches wide, having a piece of wire gauze of 900 meshes to the square inch fastened over the top. By connecting this burner by means of vulcanised indian-rubber tubing to the gas pipe, it can be moved about the table to any convenient position. The mixture of gas and air formed inside the cylinder, is to be lighted above the wire gauze ; it burns over this with a large and nearly colourless but intensely hot flame.

15. The most convenient form of iron is the ordinary box iron, made hot by heaters inside ; I decidedly give preference to that most resembling the common flat iron in shape : it ought to be tolerably heavy. Some operators recommend facing the bottom with a plate of silver ; this is very expensive and

seems to me to be attended with no advantage whatever.

16. The distilled water being one of those substances upon the purity of which success will in a great measure depend, it will be found much safer to distil it on the premises, especially as the quantity required is trifling. A convenient size for the still is about two gallons; it may be procured ready made, with worm, &c. complete, of any large dealer in chemical apparatus. The most convenient source of heat is that described above (14).

17. A platinum spatula is a most necessary instrument in almost every operation; the best size is 4 inches long,  $\frac{1}{2}$  an inch wide at one end, and  $\frac{3}{8}$  at the other, the corners being rounded off; it should be of a sufficient substance to prevent its being easily bent. Its chief use is, to raise one corner of the sheets to allow of their being held between the finger and thumb, for the purpose of removing from one dish to another, as, previous to fixing, neither the surface of the sheet, nor any of the solutions should come in contact with the fingers.

During the fixing and subsequent washing,

bone spatulas will be found very useful ; but after having been in contact with hyposulphite of soda they must be carefully kept away from any of the previous solutions, or black stains will inevitably ensue.

18. The funnels may be either of glass or porcelain : it will be found useful to have them of different sizes, from 2 inches diameter up to 6 inches. A convenient stand for them may be made of a piece of flat board, with circular holes about half the diameter of the funnels employed, drilled into it, and supported upon four legs about 8 inches high. The paper used for filtering should be the finest of the two sorts of blotting paper mentioned below (21). The filters can either be cut from the sheet as wanted, or they may be obtained ready cut in packets.

The measures should be of glass, graduated, the pint and half pint into ounces, the ounce measure into drachms, and the drachm measure into minims : they should be rather long in proportion to their width.

19. The Florence oil flasks, which can be obtained for a trifle at any oil warehouse, will be found to answer every purpose, nearly as

well as the more expensive German flasks. They must be cleansed thoroughly from the adhering oil ; this may be done by boiling in them, over the gauze gas burner, a strong solution of ordinary washing soda, and afterwards well rinsing out with water.

The scales and weights need not be of any great accuracy. A six inch beam capable of turning to half a grain, when loaded with 500 grains in each pan, will be all that is requisite ; the pans must be of glass, and the weights should consist of a set of grain and a set of drachm weights.

A sponge will be found useful for wiping up any of the solutions that may have been spilt on the bench. Solid glass stirring rods, of about the thickness of a quill and six or eight inches long, and a small Wedgwood pestle and mortar are of great service in many of the operations.

Stoppered bottles should be employed for all the solutions ; and too much care cannot be taken to label each bottle accurately and distinctly.

20. The selection of a good sample of paper for the basis on which the sensitive material is

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to be formed is of great importance, as any imperfection will be a source of annoyance in every stage of the process, and will hardly fail to show itself on the finished picture. The paper which from numerous experiments I have found to be superior to any other, is Canson's thin photographic paper. In looking over a ream of this paper, a few quires may generally be picked out of an extra thinness, and at the same time extremely hard and close grained: if the operator have it in his power, I should decidedly recommend that the paper should be looked over in this way, and only these sheets be reserved for this process; at the same time it must be remembered that the difference is hardly sufficient to make it a matter of material consequence.

21. The blotting paper should be of two kinds; namely, the ordinary white wove, for the purpose of absorbing the excess of wax from the sheets during the operation of ironing (30); and the fine filtering paper (not the Swedish) employed in quantitative chemical operations, which must be employed for drying the sensitive sheets and for filtering.

22. As an article of commerce it is very

difficult to obtain small quantities of wax sufficiently pure to be relied upon. It will be unsafe to use that which is usually met with in the form of thin round cakes about 4 inches in diameter, as in this state it is generally adulterated to the extent of *at least* 50 per cent.

If the makers were to confine their adulteration to spermaceti, as I believe they profess to do, it would not be of very much consequence; but as the price of the latter does not differ very much from that of pure wax, it is not so common an adulteration as other cheaper substances; e.g. Stearin, Stearic Acid, Tallow, Rosin, Plaster of Paris, &c. &c., which, as may be supposed, have a most injurious effect. The only way I can recommend is to apply to some large firm of known respectability, and trust to them for supplying it in a state of purity.

23. Through the kindness of several friends, amongst whom I may mention Mr. Barclay of Regent Street, and Professor Maskelyne of Oxford, I am indebted for much valuable information concerning wax and its adulterations, and for an extensive assortment of waxes

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of all kinds and in every degree of purity, together with a valuable series of the chemical bodies of which the various waxes are composed; by means of these, I have been enabled to examine the effect produced by saturating the paper with Bees' wax from different countries, Myrica wax, Canauba wax, China wax, Spermaceti, Ethal, Stearin, Stearic acid, Palmitin, Palmitic acid, Paraffin, and various oils.

24. I find that the action of the wax is purely mechanical, almost the only difference of effect produced by any of the above bodies, widely as they vary in their chemical nature, arising from a difference in their physical properties.

Stearin, Palmitin, and most of the oils, are too greasy in their nature to be advantageously employed. The fatty acids do not make the paper in the least greasy, but they injure the transparency. China wax has almost too high a melting point, and gives a crystalline structure to the paper. Spermaceti also is too crystalline. Paraffin, Ethal, and the waxes, produce very good results; of these Bees' wax is the only one that would be practically available for this purpose. It should be free from

Stearin, Stearic acid, Tallow, &c. ; the presence of a little Spermaceti, or the best olive oil, does not much interfere, and in fact an addition of the latter in small quantities is a slight improvement in cold weather, as it tends to lower the fusing point of the wax. Too much must be avoided, as it then makes the paper greasy.

25. The other chemicals, (with the exception of the strong nitric acid, which any retail druggist will supply, and the water, which had best be distilled on the premises,) should be ordered direct from some large manufacturer of photographic chemicals, as otherwise, unless the operator have a sufficient knowledge of chemistry to be able to detect any inferiority, there is danger of not having the articles sufficiently pure.

The nitrate of silver should be crystallized, not in sticks ; it ought to be perfectly dry, and have no smell, acid or otherwise.

There are usually two varieties of glacial acetic acid to be met with ; the purest must be used ; it should be perfectly free from any empyreumatic odour, and must cause no turbidity when mixed with a solution of nitrate of fil-

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ver, e. g. in making the exciting bath (51).

The gallic acid should be as nearly white in colour as possible.

Especial care should be taken to have the alcohol good; it should be 60° over proof, and of specific gravity 0.83. On evaporating a few drops on the palm of the hand, no smell should be left behind, nor should it, under the same circumstances, leave any stain on a sheet of white paper.

26. The hyposulphite of soda will be found one of the articles most difficult to obtain pure; there is a large quantity at present in the market, having little else of this salt but the name, and is of course totally unfit for use; if there be the least doubt about its purity, it should be tested in the following manner:—

Weigh out accurately 10 grains of nitrate of silver, dissolve this in half an ounce of distilled water; then add 4 grains of chloride of sodium (common salt) also dissolved in water. On mixing these two solutions together, a white curdy precipitate of chloride of silver will fall down. Next add 22 grains of the hyposulphite of soda, and allow it to stand for about ten minutes, stirring occasionally

with a glass rod. If at the end of that time the chloride of silver has dissolved, the hypo-sulphite of soda may be considered as pure. A greater or less amount of residue will indicate roughly the degree of impurity.

27. The cyanide of potassium is usually met with in the form of hard white lumps ; they will be found quite pure enough. It is very useful in removing stains formed by nitrate of silver on the fingers, &c. but the greatest care must be taken in its employment, as it is a most energetic poison ; its use in cleaning the dishes from silver stains has been pointed out above (12).



### WAXING AND IRONING.



THE first operation to be performed is to make a slight pencil mark on that side of the photographic paper which is to receive the image. If a sheet of Canson's paper be laid on a smooth table near a window, and examined from the distance of a few feet, one of its sides will be seen to have parallel bands running across it, alternately light and dark, and about one inch wide; if it now be examined closer, this same side will be found to present a finely reticulated appearance, similar to linen, especially at the corners, the other side being perfectly smooth; this latter is the side that should be marked. Either of these methods may be used; the former will be found more convenient for large sheets, and the latter for small ones.

29. The paper has now to be saturated with wax. The apparatus for this purpose has been previously described (13). The under vessel is to be half filled with boiling water, and this kept boiling by placing one of the abovementioned sources of heat (14) under it. The heat from the water communicates itself to the wax, which soon becomes liquid, and then the sheets of paper, taken up singly and held by one end, are to be gradually lowered on to the fluid. Very little care is required in this operation, even enclosing a few small air bubbles is immaterial, as the act of lifting the sheet up will generally cause the fluid wax to flow over the vacant space. As soon as the wax is absorbed, which takes place almost directly, one corner is to be raised by means of the spatula (17), taken between the finger and thumb, and then lifted up with rather a quick movement: the sheet must now be held by the corner and allowed to drain until the wax, ceasing to run off, congeals on the surface.

When the sheets are first taken up for this operation they should be briefly examined, and such as show the water mark, contain any

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black spots,\* or have anything unusual about their appearance, should be rejected.

30. The paper in this stage will contain far more wax than necessary ; the excess may be removed with very little waste by ironing them in the following manner :—First place on a smooth table about a dozen sheets of blotting paper (waste paper from previous operations will do sufficiently well) a trifle larger than the photographic paper ; then on this pad lay a sheet of clean blotting paper (21), then two sheets of plain photographic paper, next one of the sheets which has been saturated with wax (29), over this two other plain sheets, and lastly a piece of clean blotting paper.

If a hot iron (15) be now passed over the whole several times, it will be found that gradually the wax from the centre sheet will soak through the two upper sheets of paper, and completely saturate them ; and on turning over the pile of five and repeating the ironing,

\* These spots have been analyzed by Mr. Malone ; he finds them to consist, not of iron, as is generally supposed, but of small pieces of brass. I have also examined them myself with a like result.

the other two sheets will become saturated. When this has taken place the waxed sheets must be separated one from the other, and laid on one side for the second ironing ; while another pile can be waxed in the same way, using the same blotting paper, and so on until as many sheets as are needed have been once under the iron. Finally, each sheet must be separately ironed between clean blotting paper, until there are no glistening patches of wax to be seen on the surface.

31. For ironing the paper the first time, the temperature of the iron should be such that a drop of water allowed to fall on it will boil rapidly, but not roll off ; but before the iron is used for passing over the waxed sheets the second time, it should be dipped into water until the hissing entirely ceases, as it is of the utmost consequence that its temperature should not exceed that of boiling water.

This is one of the most important points in the whole process, but one which it is very difficult to make beginners properly appreciate. The disadvantages of having too hot an iron are not apparent until an after stage, while the saving of time and trouble is a great

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temptation to beginners. It is to a neglect of this point that I am inclined to attribute most of the faults so commonly laid to the charge of this beautiful process; such as gravelly appearance, or want of smoothness in the lights, and quick decomposition in the developing solution.

32. A well waxed sheet of paper, when viewed by obliquely reflected light, ought to present a perfectly uniform glazed appearance on one side, while the other should be rather duller; there must be no shining patches on any part of the surface, nor should any irregularities be observed on examining the paper with a black ground placed behind; seen by transmitted light, it will appear opalescent, but there should be no approach to a granular structure. The colour of a pile of waxed sheets is slightly bluish.



## IODIZING.



HE paper, having undergone this preparatory operation, is ready for *iodizing*; this is effected by completely immersing it in an aqueous solution of an alkaline iodide, either pure or mixed with some analogous salt.

One would think that in no part of the photographic operation would greater unanimity exist, than on the composition of the iodizing bath; but on this subject, strangely enough, no two persons seem to think alike. The formulæ for this bath are nearly as numerous as the operators themselves, and some of them show not a little ingenuity in the manner in which substances apparently the most unphotographic have been pressed into service; but, notwithstanding the formidable

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mixtures of organic and inorganic bodies which it is the fashion amongst photographers to crowd into this bath, as if complexity were all that was wanted, I am still of opinion that the simpler the bath is the better; indeed, I can scarcely imagine the use of a photographer troubling himself much about the purity of his chemicals, when instead of distilled water being the solvent, he uses London milk.

34. In all paper processes there are certain constant results which I have found attendant on the use of iodide of potassium and its analogues.

One of the difficulties most frequently complained of is what is termed *solarization*; i. e. the desired opacity of the more highly illuminated parts of the picture are lost by over exposure, and give place to a translucent red colour. This is a great inconvenience, for as it is always desirable that every object, even those in deepest shadow, should produce a corresponding impression on the paper, it becomes necessary, in order to secure these, to prolong the exposure for such a time as to risk the loss of the brighter parts.

35. I find that when pure iodide of silver

is the sensitive material, there is very little likelihood of the sky, or other light parts of the picture, becoming red, even after a very prolonged exposure; but the addition of a small proportion of a bromide, chloride, fluoride, or cyanide, is sufficient to give it this objectionable tendency.

I will not deny that a much greater degree of sensitiveness may be obtained when a small proportion of bromide of potassium, or chloride of sodium, is used in addition to the iodide; but I much prefer to submit to the slight inconvenience of waiting a few minutes longer, during the time of exposure, when the reward is the permanent gratification afforded by having a superior and more truthful negative than could have been otherwise obtained.

36. A great deal has been said, and written, about the superior sensitiveness to coloured light, which is obtained by employing bromide of silver instead of iodide; founded on some experiments by Sir J. F. W. Herschel, published in the Phil. Trans. (1840, article 77), where he states that the action of the solar spectrum on a paper prepared with bromide of silver, commences, "the moment the

rays fall upon it, visibly over its whole length, and is uniform in intensity at every point, except just at the extremities."

Now, as this effect was produced at once, and without any after application of a reducing agent, whilst in a camera picture the first effect of the light is generally invisible, requiring development to render it apparent, it becomes evident that any inference which may be drawn from the above experiments, cannot apply to the present practice of photography, unless the same spectral rays which, by a comparatively long action, will produce a visible darkening on bromide of silver, are also capable of producing a latent action on the same sensitive surface, which may be continued and rendered sensible by means of a developing agent.

37. That this is not the case is evident from a comparison between the result obtained by Sir J. Herschel (36), and my own experiments alluded to above (6), where I show that whilst iodide of silver is not acted on by the red, orange, yellow, green, or blue rays; bromide of silver is also insensible to the red, orange, yellow, and part of the green rays.

38. From these results it might, however,

seem that although for copying most coloured objects, bromine was as valueless as iodine, yet for vegetation, and other green objects, there would be a marked difference in favour of the former. This, however, is not the case. There is reflected from green vegetation such a mass of rays which equally affect bromide and iodide of silver, that the action of the narrow band of rays in which the former shows its superiority is unnoticed: and when it is remembered that, in paper processes, to employ bromides at all, there must be a large excess of an iodide, even this slight advantage disappears, and the much talked of superiority of bromine over iodine for copying colour is seen to be founded upon a too limited knowledge of the subject.

39. During the course of my experiments on this point, for the Radcliffe Observatory, several beautiful and instructive facts were brought under my notice, and as they throw much light upon the theory of this part of the process, and point out the necessity of varying the composition of the sensitive silver salt to suit the kind of light employed, I am induced to mention them rather in detail here, in the

hopes that others will pursue this interesting enquiry.

40. The results of the experiments above referred to (35) had convinced me, that for ordinary purposes iodide of silver *per se* was the best sensitive surface for receiving an image in the camera; but on making use of that body for the purpose of receiving the image in the meteorological instruments, (by employing pure iodide of potassium in the bath,) I was surprised to meet with results, for which I was at first unable to account. A little consideration, however, showed me the direction in which I was to look for a remedy. The experiments which had led me to prefer iodide of silver as a sensitive surface, had all been performed with sunlight, either direct or more frequently in the form of diffused daylight. In this case, however, coal gas was the source of light; and if, as was very probable, there were any great difference in the quality of the light from these two sources, the superiority of iodide over the bromide or chloride of silver would still be a matter for experiment.

41. A comparison of the spectra of the two kinds of light showed a very marked differ-

ence ; while in sunlight the spectral rays which are around and above the fixed line G (the indigo and higher rays) are so intense and numerous as completely to overpower the small space between and about F and G (the blue and upper portion of the green), a part of the spectrum which affects bromide more than iodide of silver ; in gas-light the case was quite different : the great bulk of photographic rays was found to lie within the limits of the visible spectrum, and consequently the photographic action of this light was likely to be far more energetic on bromide than on iodide of silver.

42. These suppositions were fully borne out by experiment: on introducing a little bromide of potassium into the iodizing bath, the change was very apparent. It required a certain proportion to be observed between the two to obtain the best results : if the iodide of potassium were in excess, the resulting silver salt was wanting in sensitiveness, requiring a comparatively long development to render an image visible ; while, if the bromide were in excess, there was a great want of vigour in the impression, the picture being red and trans-

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parent. When the proportion between the two was properly adjusted, the paper was extremely sensitive, the picture presenting a vigorous black appearance, without the least approach to red. I found that the best results were obtained on mixing the iodide and bromide of potassium in the proportion of their atomic weights.

43. The iodizing bath that I have found to give the most uniform and vigorous negatives, when the objects are illuminated by sun or daylight, is made in the following manner:—

Take

|                     |           |      |
|---------------------|-----------|------|
| Iodide of Potassium | 1000 grs. | 1326 |
| Iodine . . . .      | 10        | 129  |
| Distilled Water . . | 1 quart   | 2043 |

Dissolve the iodide of potassium in a few ounces of the water, and then add the iodine. As soon as it has dissolved, which it will readily do if it be stirred about, add the rest of the water, and the bath will be fit for use.

44. This bath will remain good to the last drop: it will, however, require to have iodine added to it in small quantities from time to time. This will be most conveniently done

by taking about half a pint of the bath, in a separate bottle, and adding to it a great excess (say a quarter of an ounce) of iodine : this will render the supernatant liquid nearly black and whenever the bath requires replenishing with iodine, a few drops of the above strong solution will suffice to bring it to the proper colour, which should be that of pale sherry.

This solution must be poured, or filtered, if necessary, into a rather deep dish (10) and then the waxed and ironed sheets are to be completely immersed in it, in the proportion of twelve or fourteen sheets of 11 by 9 inches to the above quantity of liquid.

45. At first a slight difficulty may be felt in immersing them without enclosing air bubbles ; the greasy nature of the surface preventing any immediate adhesion of the liquid.

The paper should be held by one end, and then gradually laid down on the surface of the bath, commencing at the other end ; the paper ought not to slant towards the surface of the bath, or there will be danger of enclosing air bubbles ; but while it is being laid down, the part out of the liquid should be kept as nearly

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as possible at right angles with the part which is already floating on the surface ; any curling up of the sheet when first laid down, may be prevented by breathing on it gently. In about ten minutes, the sheet ought to be lifted up by one corner, and turned over in a similar way ; a slight agitation of the dish will then throw the liquid entirely over that sheet, and another can be treated in like manner.

Before the sheets have been in this bath many minutes, the iodine, uniting with the starch with which the paper is sized, will have turned them to such a deep purple colour as to appear almost black.

46. They must remain soaking for three or four hours ; several times during that interval, (and especially if there be many sheets in the same bath,) they ought to be moved about and turned over singly, to allow of the liquid penetrating between them, and coming perfectly in contact with every part of the surface. After they have soaked for a sufficient time, the sheets should be taken out and hung up to dry ; this is conveniently effected by stretching a string across the room, and hooking the papers on to this by means of a large

sized pin (known as *blanket* pin) bent into the shape of the letter S. The point of the pin should be run through one corner of the paper and then the head hooked over the stretched line.

After a sheet has been hung up for a few minutes, a piece of blotting paper, about one inch square, should be stuck to the bottom corner to absorb the drop, and prevent its drying on the sheet, or it would cause a stain in the picture.

47. While the sheets are drying, they should be looked at occasionally, and the way in which the liquid on the surface dries, noticed ; if it collects in large drops over the surface, it is a sign that the sheets have not been sufficiently acted on by the iodizing bath, or have been removed from the latter too soon ; and if, when looked through, they are not of a uniform deep purple colour, but clouded and uneven, it shows that there has been some irregular absorption of the wax, or defect in the iodizing : it will be as well to reject sheets so marked.

48. As soon as the sheets are quite dry, they can be put aside in a box for use at a

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future time. There is a great deal of uncertainty as regards the length of time the sheets may be kept in this state without spoiling ; I can speak from experience as to there having been no sensible deterioration after a lapse of ten months, but further than this I have not tried.

Up to this stage, it is immaterial whether the operations have been performed by daylight or not ; but the subsequent treatment, until the fixing of the picture, must be done by yellow light (8).



## EXCITING.

**T**HE next step consists in rendering the iodized paper sensitive to light. Although, when extreme care is taken in this operation, it is hardly of any consequence when this is performed ; yet in practice, it will not be found convenient to *excite* the paper earlier than about a fortnight before its being required for use.

The materials for the exciting bath are nitrate of silver, glacial acetic acid, and water. It is of little importance what be the strength of the solution of nitrate of silver ; the disadvantages of a weak solution are, that the sheets require to remain in contact with it for a considerable time before the decomposition is effected, and the bath requires oftener renewing ; while with a bath which is too strong, time is equally lost in the long-continued washing

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requisite to enable the paper to keep good for any length of time. The quantity of acetic acid is also of little consequence.

50. In the following bath, I have endeavoured so to adjust the proportion of nitrate of silver, as to avoid as much as possible both the inconveniences mentioned above,

Nitrate of silver . . 300 grains.

Glacial acetic acid . . 120 grains.

Distilled water . . 20 ounces.

The nitrate of silver and acetic acid are to be added to the water, and when dissolved, filtered into a clean dish (12), taking care that the bottom of the dish be flat, and that the liquid cover it to the depth of at least half an inch all over; by the side of this, two similar dishes must be placed, each containing distilled water.

51. A sheet of iodized paper is to be taken by one end, and gradually lowered (45), the marked side downwards, on to the exciting solution, taking care that no liquid gets on to the back, and no air bubbles are enclosed. It will be necessary for the sheet to remain on this bath from five to ten minutes; but it can generally be known when the operation

is completed by the change in appearance, the purple colour entirely disappearing, and the sheet assuming a pale, homogeneous straw colour.

52. When this is the case, one corner of it must be raised up by the platinum spatula, lifted out of the dish with rather a quick movement, allowed to drain for about half a minute, and then floated on the surface of the water in the second dish, while another iodized sheet is placed on the nitrate of silver solution; when this has remained on for a sufficient time, it must be in like manner transferred to the dish of distilled water, having removed the previous sheet to the next dish.

53. A third iodized sheet can now be excited, and when this is completed, the one first excited must be perfectly dried by pressing between folds of clean blotting paper (21), wrapped up in clean paper, and preserved in a portfolio until required for use; and the others can be transferred a dish forward, as before, taking care that each sheet be washed twice in distilled water, and that at every fourth sheet the dishes of washing water be emptied, and replenished with clean distilled

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water ; this water should not be thrown away, but preserved in a bottle for a subsequent operation (63).

54. The above quantity of the exciting bath, will be found quite enough to excite about thirty sheets of the size  $11 \times 9$  inches, or 3000 square inches of paper. After the bulk has been exhausted for this purpose it should be kept, like the washing waters, for the subsequent operation of developing (63).

Of course these sensitive sheets must be kept in perfect darkness. Generally, sufficient attention is not paid to this point. It should be borne in mind, that an amount of white light, quite harmless if the paper were only exposed to its action for a few minutes, will infallibly destroy it if allowed to have access to it for any length of time ; therefore, the longer the sheets are required to be kept, the more carefully must the light, even from gas, be excluded ; they must likewise be kept away from any fumes or vapour.



## EXPOSING IN THE CAMERA.

**N**ERY few rules can be given for regulating the time of exposure in the camera ; the operator must rely on his own experience, which will not be too dearly bought with the sacrifice of the first two or three pictures. With a Ross' three inch landscape lens and half-inch stop, I should expose for between five and ten minutes on a bright day without much fun.

I prefer to employ as much as possible the same sized diaphragm (half an inch will be found a very good aperture for a lens of 12 or 14 inches focus), as then, the light which enters the camera being tolerably uniform for equally bright days the time of exposure can be better regulated.

56. On account of the iodizing bath being

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of such a simple composition the time of exposure will bear varying within extremely wide limits without much interfering with the ultimate beauty of the negative. Thus, under the circumstances mentioned above, an exposure of either three or twenty minutes would equally have given a picture, and, by care and attention during the development, neither of them would have been much inferior to one which had received the proper time of exposure.

57. It is a curious fact, and one which I have frequently found useful, that when the sensitive surface consists of iodide of silver, and objects are being copied which present great contrasts of light and shade; the photographic effect of the light radiated from the faintly illuminated objects, will increase in a much greater ratio than the effect from the brighter objects. Thus, after a very short exposure, only the brighter parts will be seen on developing; if the exposure be longer, there will be a stage at which the relative intensities of light and shade are true to nature: and by still more prolonging the exposure, the difference between the light and dark parts of the picture will become less and less, until

ultimately they will meet in one uniform opaque black.

58. It is both interesting and instructive to look over a collection of photographs and notice the differences between one picture and another as regards exposure. Alas! for the patience of photographers: upwards of eighty per cent will show unmistakable signs of being under exposed, whilst those which have been over exposed will be but a very small fraction of the remainder.

59. In skilful hands a knowledge of these facts may often be turned to great advantage. Slight under exposure, sufficient to produce a trifling exaggeration in the contrast of light and shade, without, however, losing all detail in the shadows, adds considerably to the vigour and artistic beauty of the picture, and may frequently, and not unjustifiably, be resorted to in the absence of sunshine. Whilst for copying masses of foliage or other photographically dark objects, acquaintance with the effect of over exposure, will often, with judgment, be found useful in obtaining a correct representation of the visible variations in light and shade; for although iodide of silver

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is not sensitive to green light, still on analysing with a prism the light reflected from masses of vegetation, I have found it to be far from homogeneous, there being in every case sufficient active rays present to affect this sensitive compound.



## DEVELOPING.

**U**NLESS the exposure to light has been extremely long, nothing will be visible on the sheet after its removal from the camera, more than there was previous to exposure ; the action of the light merely producing a latent impression, which requires to be *developed* to render it visible.

61. The developing bath in every case consists of an aqueous solution of gallic acid, with the addition, more or less, of a solution of nitrate of silver.

An improvement on the ordinary method of developing with gallic acid, formed the subject of a communication to the Philosophical Magazine for March 1855, where I recommend the employment of a strong alco-

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holic solution of gallic acid, to be diluted with water when required for use, as being more economical both of time and trouble than the preparation of a large quantity of an aqueous solution for each operation.

62. The solution is thus made: put two ounces of crystallized gallic acid into a dry flask with a narrow neck; over this pour six ounces of good alcohol, ( $60^{\circ}$  over proof,) and place the flask in hot water until the acid is dissolved, or nearly so. This will not take long, especially if it be well shaken once or twice. Allow it to cool, then add half a drachm of glacial acetic acid, and filter the whole into a stoppered bottle.

63. To obtain a solution of about the same strength as a saturated aqueous solution, half a drachm of the above would require to be added to two ounces of water, but for this purpose I prefer a weaker bath, which is prepared by mixing together five ounces of the water that has been previously used for washing the excited papers (53), and four drachms of the exhausted exciting bath (54); the mixture is then to be filtered into a perfectly clean dish, and half a drachm of the above

alcholic solution of gallic acid poured into it. The above quantities are sufficient to develop one sheet of the size  $11 \times 9$  inches.

64. The dish must be shaken about until the greasy appearance has quite gone from the surface; and then the sheet of paper may be laid down on the solution in the ordinary manner, with the marked side downwards, taking particular care that none of the solution gets on the back of the paper, or it will cause a stain. Should this happen, either wipe it off carefully with blotting paper, or immerse the sheet entirely in the liquid.

65. If the paper has been exposed to a moderate light, the picture will begin to appear within five minutes of its being laid on the solution, and will be finished in an hour. It may however sometimes be requisite, if the light has been feeble, to prolong the development for a day or more. If the dish be perfectly clean, the developing solution will remain active for the whole of this time; and when used only for a few hours, will be quite clear and colourless, or with the faintest tinge of brown; a darker appearance indicates the presence of dirt. The progress of the de-

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velopment may be watched, by gently raising one corner with the platinum spatula, and lifting the sheet up by the fingers. This should not be done too often, as there is always a risk of producing stains on the surface of the picture. I prefer allowing the development to go on, until the colour is rather more intense than is ultimately required, as it is generally toned down in the fixing bath.

66. According to the behaviour of the picture in this bath, the operator can judge of the kind of exposure that it has received.

If the sheet has been exposed for an insufficient time the picture will be tardy in making its appearance, and then only the brighter parts of the object will be rendered visible. Long continued development will seldom have any other effect than increasing the opacity of these parts, the objects which are at all in shadow remaining permanently invisible. There will be a nearly total absence of half tint, and the sheet will generally appear remarkably clean, while the division between opaque black and clear white will be abrupt and sharp.

67. The appearance of an over exposed

sheet is nearly the converse of the above. The picture makes its appearance very rapidly, and at first seems to promise a good negative; all the detail, even of objects in deep shadow, being soon visible. Gradually, however, a mist seems to come over those parts which ought to remain transparent, and then the light parts begin to get darker and darker, without a corresponding deepening in intensity of the dark parts, until, as noticed above (57), the distinction between light and shade is nearly lost.

68. The development of a sheet which has been exposed for the proper time is nearly intermediate in appearance between that of under and over exposure. The high lights make their appearance first; very soon after they are followed by the next strongly illuminated objects, and then by all the other parts in the order of their brightness. The relative intensities of light and shade are always truly preserved (inversely of course) and the darkening goes on increasing regularly and quickly.

69. As soon as the picture is judged to be sufficiently intense, it must be removed from

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the gallo-nitrate, and laid on a dish of water, (not necessarily distilled). In this state it may remain until the final operation of fixing : this need not be performed immediately, if inconvenient, as after being washed once or twice, and dried between clean blotting paper, the picture will remain unharmed for weeks, if kept in a dark place.



## FIXING.

**T**HE *fixing bath* is composed of a saturated solution of hyposulphite of soda diluted with its own bulk of water. Into this the sheets are to be completely immersed, until the whole of the yellow iodide of silver has been dissolved out. This operation need not be performed by yellow light; daylight is much better for showing whether the picture be entirely fixed. This will take from a quarter of an hour to two hours, according to the time the bath has been in use.

It will be well not to put too many sheets into the bath at once, in order to avoid the necessity of turning them over to allow the liquid to penetrate every part.

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When fixed, the sheet, if held up between the light and the eye, will present a clear semi-transparent appearance in the white parts.

The fixing bath gradually becomes less and less active by use, and then its action is very energetic on the dark parts of the picture, attacking and dissolving them almost as much as the unchanged iodide. When this is the case it should be put on one side, and a fresh bath made.

71. After removal from the fixing bath, the sheets must be well washed. In this operation, the effect depends more upon the quantity of water used, than upon the duration of the immersion. When practicable, it is a good plan to allow water from a tap to flow over each side of the sheets for a minute or two, and having thus got rid of the hypo-sulphite of soda from the surface, to allow them to soak for half an hour in two or three changes of warm water, and lastly, for about ten minutes in a large dish of hot water.

72. They are then to be dried by hanging up by a crooked pin, as after iodizing (46). When dry, they will present a very rough and granular appearance in the transparent parts;

this is removed by melting the wax, either before a fire, or, what is far better, by placing the sheets between blotting paper, and passing a warm iron over them ; by this means, the white parts will recover their original transparency.

FINIS.

